

The Genus *Lepidozona* in the Panamic Province, with the Description of Two New Species

(Mollusca : Polyplacophora)

BY

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(6 Plates)

IN THE COURSE OF EXAMINING material accumulated by me in about 5 years of collecting in the Gulf of California, Mexico, and on the west coast of Central America, I have come across a number of species of chitons not hitherto recognized. Since 2 of these species appeared to belong to the rather ill-defined genus *Lepidozona* Pilsbry, 1892, it became the purpose of this report to consider not only the 2 new species of chitons but other representatives of *Lepidozona* in the Panamic province as well, with a view to a better characterization and understanding of this very interesting group.

Class POLYPLACOPHORA de Blainville, 1816

Subclass NEOLORICATA Bergenhayn, 1955

ISCHNOCHITONINAE Bergenhayn, 1930

ISCHNOCHITONIDAE Dall, 1889

Lepidozona Pilsbry, 1892

HISTORY AND DESCRIPTION

1. PILSBRY (1892: 125) established *Lepidozona* as a section of the subgenus *Ischnochiton* s. s. with *Chiton mertensii* Middendorff, 1847 as the type species by monotypy. As a synonym, he included *Lepidopleurus* Carpenter, 1873; DALL, 1879 (pp. 331 - 332) (not of Leach in Risso, 1826; not of CARPENTER, 1857; nor of H. & A. ADAMS, 1858). PILSBRY (l. c.) characterized *Lepidozona*: "Valves having sharp but somewhat rugose and thick insertion teeth, and (typically) the sinus is delicately toothed within. Girdle

covered with convex scales, usually smoothish. Type *I. mertensii*." And he added that this section "differs from *Ischnochiton* not only in having the girdle scales convex and smooth or but slightly striated, but also in the toothed sinus. It is, however, an artificial group, the species being more closely related to a number of diverse *Ischnochitons* than to each other. Numerous transitions from the smooth convex scales to flat striated scales occur, the variation in degree of striation being considerable in some species."

2. PILSBRY (1893b: 82) added to the definition of *Lepidozona*: "Ischnochitons having the girdle-scales strongly convex, smooth or striated; valves with a lamina across the sinus, separated from the sutural laminae by a notch, and often denticulate; teeth subrugose; mucro low, inconspicuous, nearly flat, subcentral. Sculpture consisting of pustules or graniferous ribs on lateral areas and end valves, and longitudinal riblets on the central areas, the interstices usually latticed." He concluded that the section *Lepidozona* "as here amended, is a very useful one, comprising *Ischnochitons* of the *mertensii* group on the west coast of America, and the *coreanicus* group on the Sino-Japonic shores."

3. BERRY (1917a: 229 - 248) was the first to use *Lepidozona* as a subgenus of *Ischnochiton* Gray, 1847. In a later paper, BERRY (1917b: 1 - 8) pointed out that "it would not be surprising if *Lepidozona* should later on require elevation to generic order."

4. THIELE (1933: 18) seemingly impressed by the characteristics of the radula, removed *Lepidozona* from the *Ischnochiton* group to place it as a subgenus of *Lorica* H. & A. ADAMS, 1852, along with *Lorica* s. s., *Callisto-chiton* Carpenter in Dall, 1882, *Squamophora* Nierstraß,

1905, and *Loricella* Pilsbry, 1892. Thiele divided the so-called subgenus *Lepidozona* into 3 sections: *Lepidozona* s. s., *Solivaga* Iredale & Hull, 1925, and *Rhombochiton* Berry, 1919. Thiele's systematic arrangement of *Lepidozona* has found no acceptance by other workers.

5. BERGENHAYN (1933: 15) was the first to elevate *Lepidozona* to full generic rank. He described the genus as follows (my translation): "Oval shaped, arched shell; $H = 0.9 - 0.5$. Sculpture of strong ribs radially placed in valve *i*, lateral areas, and posterior area of valve *viii*; central areas with longitudinal ribs, sometimes with a lattice sculpture. Articulation with insertion plates and sutural laminae. Girdle scales strongly convex. Radula medial tooth with a broad front blade; first lateral tooth with small prominence immediately behind antero-lateral corner; second lateral tooth with one pointed blade. Gills abanal and merobranchial."

6. *Solivaga* IREDALE & HULL (1925: 351, 354 - 355). Type, by monotypy, *Callistochiton finschi* Thiele (1910: 36; pl. 8, figs. 57 - 60, from Sumatra in the Java Sea). Placed in synonymy by A. G. SMITH (1960: 56).

7. *Gurjanovillia* YAKOVLEVA (1952: 6, 97). Type, by original designation, *Chiton albrechtii* Schrenck, 1867. As noted by A. G. Smith (personal communication): "This genus, with *albrechtii* from Japan as type, does not appear to be appreciably different from *Lepidozona* Pilsbry. TAKI (1938) classifies both *mertensii* and *albrechtii* as *Lepidozona*. As the differences relied upon to validate *Gurjanovillia* Yakovleva seem less than generic in importance, I would place this genus in synonymy with *Lepidozona*. AGS IV/57." Synonymized, A. G. SMITH (1960: 56).

Type Species: *Chiton mertensii* Middendorff, 1847a: 118, by OD, PILSBRY, 1892: 125.

Redescription: Chitons, small to medium in size (up to 5 cm), oval, medium- to high-arched.

Tegmentum tends to be finely granulose and conspicuously sculptured. Anterior valve with many (often more than 20) radial ribs, usually pustulose or graniferous, distinctly separated from each other. Posterior valve with low, flat, inconspicuous, central or subcentral (slightly anterior) mucro; post-mucro area plane or somewhat concave, radially ribbed in the manner of the anterior valve. Intermediate valves with well defined, moderately raised lateral areas. Central area well sculptured with longitudinal riblets, often with less accentuated cross-ribbing and a lattice effect; the longitudinal riblets display a tendency to diverge forward. On the second valve, the forward diverging riblets of the jugal tract are often

seen to outline a wedge-like figure that may overlap and supercede the more longitudinally disposed riblets of the adjacent area.

This "wedge" figure on the second valve seems to be a rather frequent feature of *Lepidozona*, a feature that I have had no occasion of noticing in members of any other genus.

Lateral areas display radial ribs - usually more than 2 ribs per area -, ribs that tend to twin, and are similar in structure to those of the anterior and posterior valves; the posterior border of the lateral area tends to be straight or undulating in profile, the undulations (dentations, serrations, crenations) corresponding to and resulting from the often well developed pustules or granules in the posterior rib.

Articulation usually whitish in color. Anterior and posterior valves with multiple (around 10 or 12) well-defined slits; intermediate valves with one slit on each side. Insertion teeth neatly cut, sharp, straight edged, but somewhat rugose and thick. Eaves tend to be solid, not spongy, overhanging moderately about as far as the insertion teeth. Sutural laminae sharp, well developed, semi-oval to triangulate. Sinus well defined; the sinus lamina often denticulate along the free edge, may or may not be notched at the junction with the sutural laminae. Girdle of imbricated, fair-sized scales. The girdle scales may be either (1) large, strongly convex, surface smooth or minutely granulose (sometimes obsoletely striated), often mammillated, that is with a small but conspicuous nipple-like prolongation on their dorsal edge, or (2) smaller, flatter, more definitely oval, and conspicuously striated.

Remarks: The whole group of chitons subsumed under the generic name *Lepidozona* seems to be now a well defined, natural group, certainly much more than "a temporary expedient for convenience in identifying species" as PILSBRY (1892: 125) characterized it at its inception.

Lepidozona seems to have strong affinities with two other genera, *Ischnochiton* Gray, 1847 (from which it is distinguished mostly by the sculpture of the tegmentum), and *Callistochiton* Carpenter in Dall, 1879 (from which it is separated mostly by the characteristics of the articulation). Although several conchological features appear to be quite valuable in the definition of the genus *Lepidozona* (many radial pustulose ribs on end valves and lateral areas; longitudinal riblets and latticing in the central areas; single slits on the intermediate valves, and about 10 slits on the end valves; denticulated and notched sinus laminae, etc.), it is apparent that no single character could be regarded as exclusive or typical of the genus. Even a sinus notched and "delicately toothed within" is not at all typical as suggested by PILSBRY (1892: 125).

Still, two features of *Lepidozona* seem to deserve special emphasis, not only because they have been somewhat understated in the literature, but also for their relative importance as generic characters. One of these features is the "wedge" figure on the second valve. This figure represents the culmination of the general tendency of the longitudinal riblets in *Lepidozona* to diverge forwardly. On the second valve, the forward divergence of the jugal longitudinal riblets is particularly marked in several species of *Lepidozona*, outlining a wedge-shaped figure which often seems to overlap and supercede the much less divergent longitudinal riblets of the adjacent central area. In some cases, this wedge figure is visually accentuated by a difference in the color of the tegmentum.

The other remarkable feature of *Lepidozona* is the conspicuous prolongation, nipple-like, found on the dorsal edge of the girdle scales in some species, such as *L. mertensii* (the type species of the genus), *L. clathrata*, and *L. formosa*. Its presence in *L. mertensii* had already been noticed by MIDDENDORFF (1847b: 125 - 127; plt. 14); although the feature was not mentioned in the text, the nipple-like prolongation was clearly shown in the drawing of the girdle scale, figure 2-d. BERGENHAYN (1933: 17; fig. 5-c) observed similar prolongations on the dorsal girdle scales of *L. pectinella*. The feature was also noticed by TAKI, 1938, who mentioned it as a "process at the front end" of the girdle scales (p. 392), and illustrated it in the case of *L. mertensii*, *L. albrechtii*, and *L. coreanica*, in plate XXXI, figs. 3, 5, 7, and 9. LELOUP (1941: 1 - 15) made similar observations in *L. biscalptus* (Pilsbry, 1892), and *L. berryanus* Leloup, 1941 [= *L. pilsbryana* (Berry, 1917)], fig. 2-A and fig. 3-Aa. YAKOVLEVA, 1952, observed and illustrated the same nipple-like process in the girdle scales of *L. albrechtii* (*op. cit.*: 98; fig. 48), *L. kobjakovae* (*op. cit.*: 100; fig. 51) and *L. lindbergi* (*op. cit.*: 101; fig. 52).

It seems that species of *Lepidozona* are confined to the subtidal zone, from low intertidal to a few hundred meters, often on the underside of rocks.

Species of *Lepidozona* have been described mostly from the eastern and western Pacific Ocean to Australia. It is a curious fact that only a very few species have been reported in the Atlantic Ocean; KAAS, 1972, cited no *Lepidozona* in his rather thorough review of the Polyplacophora of the Caribbean region.

As of this writing, 6 species of *Lepidozona* have been recognized in the Panamic faunal province:

- Lepidozona allynsmithi* Ferreira, spec. nov.
- Lepidozona clathrata* (Reeve, 1847)
- Lepidozona crockeri* (Willett, in Hertlein & Strong, 1951)
- Lepidozona formosa* Ferreira, spec. nov.
- Lepidozona serrata* (Carpenter, 1864)
- Lepidozona subtilis* Berry, 1956

Lepidozona clathrata (Reeve, 1847)

(Figures 1, 2, 3, and 4)

- Chiton clathratus* Reeve, 1847. Conch. Icon., plt. 18, fig. 113
- Lepidopleurus clathratus*. CARPENTER, 1857: 195 [= *Ischnochiton subclathratus* Pilsbry, 1892]
- Ischnochiton clathratus*. PILSBRY, 1892: 128; plt. 26, figs. 31 to 34 (in part); included in section *Lepidozona*. — OLDROYD, 1927, 2 (3): 282, in section *Lepidozona*. — LOWE, 1935: 32
- Ischnochiton (Lepidozona) clathratus*. BERRY, 1931: differentiated *I. (L.) clathratus* from *I. (L.) californiensis* Berry, 1931. — STEINBECK & RICKETTS, 1941: 553; plt. 26, fig. 5
- Lepidozona clathrata*. KEEN, 1958: 526 - 527; no. and fig. 39. — DUSHANE, 1962: 50. — DUSHANE & SPHON, 1968: 244 - 245. — THORPE in KEEN, 1971: 873 - 874; no. and fig. 31

Nomenclatural Comments: PILSBRY (1893a: 129) placed *Lepidopleurus pectinatus* Carpenter, 1866 (not *L. pectinatus* Carpenter, 1864 [= *Ischnochiton cooperi* Carpen-

Explanation of Figures 1 to 4

Lepidozona clathrata (Reeve, 1847)

- Figure 1: Hypotype "A" (in text), 38.5 mm long
- Figure 2: Close-up view of shell of specimen in Figure 1, to show lateral and central areas
- Figure 3: SEM photographs of girdle scales and adjoining valve ii of hypotype "B" in text approximately $\times 75$
- Figure 4: Close-up of girdle scales of same specimen as in Figure 3 approximately $\times 150$

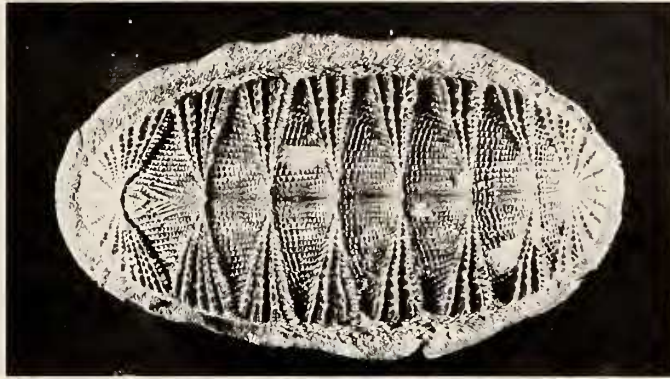


Figure 1

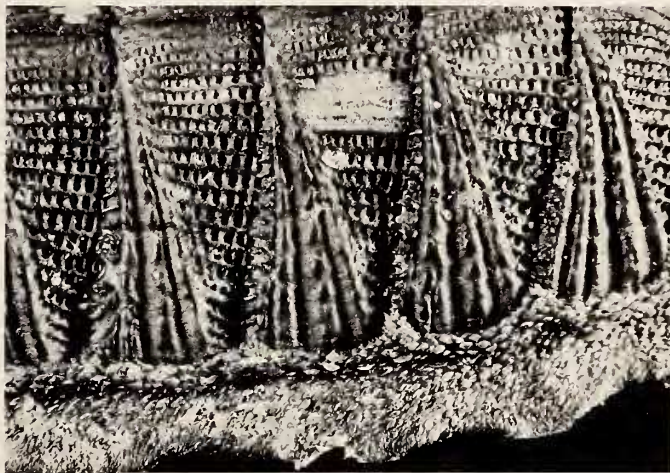


Figure 2

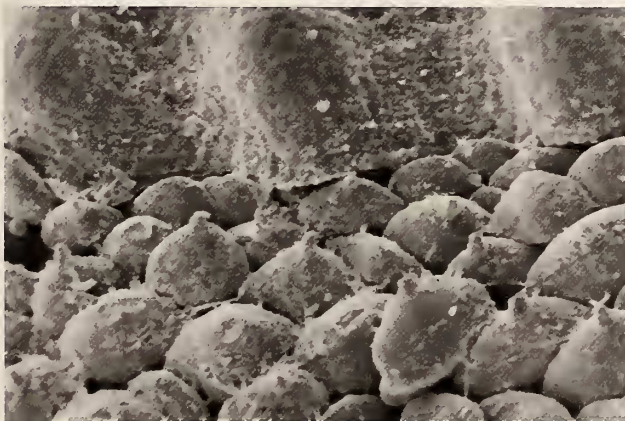


Figure 3



Figure 4

ter]; nor *Chiton pectinatus* Sowerby, 1840) in synonymy with *Chiton clathratus* Reeve, 1847.

The name *pectinatus* being preoccupied, *pectinulatus* was substituted for it by CARPENTER in PILSBRY, 1893a: 129. It is fairly clear that by *Lepidozona pectinulatus* Carpenter had referred to the species later known as *L. californiensis* Berry, 1931. For, seemingly, Carpenter's specimens were all from Catalina and Santa Barbara Islands, well recognized localities for *L. californiensis*, but not at all for *L. clathratus*. However, an element of confusion crept into the picture when PALMER, 1958, found at the Redpath Museum two complete specimens of the species and 3 separate plates labeled by Carpenter as "Type la Paz Pease". Palmer, faced with this apparent nonconformity, suggested that "the locality with the type specimens must be in error, or a misplacement of labels" must have taken place. I consider that with Palmer's opinion the matter should be laid to rest, particularly since the photograph of one of these type specimens, in PALMER, 1958: plt. 31, figs. 5 and 6, appears to be that of a typical "*californiensis* Berry."

Thus, it seems evident that, unwittingly, Pilsbry included both *Lepidozona clathratus* from the Gulf of California, and *L. californiensis* from southern California in *Ischnochiton clathratus* (Reeve, 1847); in some unpublished notes conveyed to Allyn G. Smith (personal communication) through R. Tucker Abbott, then with the Philadelphia Academy of Natural Sciences, Pilsbry apparently acknowledged that in fact he was in error in considering "Reeve's unlocalized *C. clathratus* to be the California species."

The confusion was compounded when PILSBRY (1892: 124 - 125), regarding *Lepidopleurus clathratus* Carpenter, as a species distinct from *Chiton clathratus* Reeve, 1847, renamed Carpenter's species *subclathratus* and placed it in the subgenus *Ischnochiton* s. s. BERRY (1931: 255) and KEEN (1958: 521) kept the two names, *clathratus* Reeve, 1847, and *subclathratus* Pilsbry, 1892, as if belonging to separate species. However, *L. clathratus* Carpenter, 1857, was based on "one very small specimen . . . on a stone" which had lost its anterior valve. From CARPENTER's (1857: 195) description, and subsequent comments (CARPENTER MS in PILSBRY, 1892: 124 - 125), it is fairly evident that Carpenter had redescribed a juvenile specimen of *Chiton clathratus* Reeve, 1847, now transferred to the genus *Lepidozona* Pilsbry. I am indebted to Allyn G. Smith for pointing out this relationship to *L. clathrata* (Reeve), a relationship which is already apparent in Carpenter's camera lucida drawing in BRANN (1966: 45; plt. 20, fig. 253) and further supported by a photograph and sketches of the type specimen made by Myra Keen at the British Museum (Natural History), and now

part of A. G. Smith's own "Chiton Notes" (personal communication).

Diagnosis: Chitons of medium size; a dingy dark green or olivaceous brown, often clouded with black. End valves and lateral areas with radial ribs made up of rows of round to bar-like pustules. Central areas with longitudinal riblets, clearly cross-ribbed, with a clathrate effect.

Type Material: "Mus. Cuming" (REEVE, 1847). The possibility of its being lost must be seriously considered, since I have been unable to confirm its location at the British Museum (Natural History).

Type Locality: Not stated by REEVE, 1847: "Hab.: ?". PILSBRY, 1892, gives it as "Monterey and San Diego, California, to La Paz, L. California," which is obviously in error. BERRY, 1931, simply places "true *clathratus* Reeve" in the Panamic Province.

The type locality is here restricted to San Felipe (latitude 31°03'N; longitude 114°49'W), in the Gulf of California, Baja California Norte, Mexico.

Description: Hypotype "A" (Figures 1 and 2) - Oval in outline. Shell and girdle of a rather uniform dingy, olive-brown color, with somewhat darker tones along the jugum; the girdle shows only the faintest indication of banding. The dried but fully extended specimen measures 38.5 mm in length, 22.6 mm in width (at the level of iv), and 6.0 mm in height. Jugal angle 110°.

Tegmentum's general surface minutely granulose. Anterior valve shows 20 radial ribs (some twinned), each made up of well defined pustules, some round, some elongated, with a tendency to fuse into longer bars. However, each such radial rib is clearly separated from adjacent ones by a space as large or larger than the diameter of the pustules themselves. A fine sulcus often marks the boundary between two adjacent radial ribs. The intermediate valves ii to vii show reasonably elevated lateral areas bearing 4 to 5 ribs, with similar pustules, mostly fused into long bars. The posterior border of the lateral areas is mostly crenated in correspondence with pustules in the posterior ribs. The central areas display 16 to 18 longitudinal riblets to a side; these riblets tend to diverge forward, and to become moderately oblique at the outer margins of the valve. On valve ii, the longitudinal riblets of the jugal tract are conspicuously divergent forwardly, and so create a sort of wedge-like figure that overlaps and supersedes the "underlying" riblets. Throughout the central area, the longitudinal riblets are crossed by about 10 to 12 finer transverse riblets, producing a very definite clathrate appearance. The posterior valve is sculptured in conformity with the other valves; the muero is central

and well defined, although not appreciably raised; the post-mucro area is slightly concave, with 16 radial, similarly pustulose ribs.

The girdle is about 3.0 mm wide, covered with imbricating scales whose largest diameter attains 0.53 mm near the valves' margins. The scales are strongly convex. Many scales display a pointed prolongation arising from the dorsal edge (Figures 3 and 4), an observation hitherto not described. These nipple-like formations are particularly noticeable under the Scanning Electron Microscope (SEM), although also clearly visible with an ordinary microscope with fairly strong ($\times 60$) magnification. Most scales appear to have a smooth or minutely granulose surface; however, here and there a few scattered scales display some faint and often doubtful striation.

The articulamentum is white, although with a pale bluish overcast. Sutural laminae are broadly triangular and moderately short. Sinus laminae show a few (up to 7) weak pectinations; on valve ii, the sinus lamina is separated from the adjacent sutural laminae by a small notch. Insertion teeth are sharp and short. Slit formula is 12-1-12. The interior of valves i and viii show an intense brownish pigmentation at the umbo.

The specimen was collected by Antoinette and Roger Schock and myself on February 28, 1971, at San Felipe, Baja California Norte, Mexico, at a point referred to as Ensenada Blanca, immediately north of Punta San Felipe, where the species is relatively abundant at low water level, on the undersides of rocks.

Hypotype "B", used for the SEM micrographs (Figures 3 and 4) is part of the same lot; it measures, dry but fully extended, 30.2×18.1 mm. Both specimens have been deposited in the California Academy of Sciences, Department of Geology (CASG) Type Collection (No. 55072).

Individual Variation: In coloration, *Lepidozona clathrata* seems remarkably uniform and to vary only within narrow limits. All specimens examined were of a rather dingy color, varying slightly between dark olive and dark brown. A few specimens collected at Bahía San Francis-

quito, Baja California (AJF-35, June 1973) were of an intense dark blue-violet color. Variation in meristic characters, such as the number of radial ribs, number of slits, etc., is summarized in Table 1. The definition and size of the pustules in the radial ribs in the end valves and lateral areas were observed to vary considerably from specimen to specimen, from round pustules to long oval bars often fused into crests. The clathrate aspect of the central areas varied very little and was well marked in all specimens examined. Juvenile forms of *L. clathrata* as small as 8 mm already exhibit enough characteristics of the species to allow for easy identification.

Distribution: *Lepidozona clathrata* is confined to the northern part of the Panamic faunal Province, being particularly abundant in the Gulf of California. The literature and the collections of the California Academy of Sciences, Allyn G. Smith, George Hanselman, and my own (AJF) reveal its presence throughout the Gulf of California from, on the west side, San Felipe (where it is particularly abundant) to Puertecitos, Bahía San Luis Gonzaga, Bahía de los Angeles, Bahía San Francisquito, Puerto Escondido, La Paz, and Buena Vista (Cape region); on the east side in the Puerto Peñasco and Guaymas areas; in the islands of Tiburon, San Esteban, Angel de la Guardia (Puerto Refugio), Partida (north of Isla Raza), San José, Espíritu Santo, and Cerralvo. The southernmost extension of the range of the species seems to be at about latitude 19° N, as represented in collections from Islas Tres Marias (George Hanselman, personal communication), Punta Mita, Nayarit (Laura and Glenn E. Burghardt collection), and Manzanillo, Colima (American Museum of Natural History, ex "Zaca" expedition, 1938; William Old, personal communication). C. B. ADAMS (1852: 242) cites finding in Panama 12 specimens of a species of chiton that he identified as *Chiton clathratus* Reeve, 1847; since those specimens are no longer available and there has been no further evidence that *L. clathrata* would occur that far south, I regard the citation as the result of a misidentification, an opinion already expressed by PILSBRY (1893a: 268-269).

Explanation of Figures 5 to 8

Lepidozona formosa Ferreira, spec. nov.

Figure 5: Holotype, 28.0 mm long

Figure 6: Holotype. Close-up of lateral and central areas

Figure 7: SEM photograph of girdle scales adjoining valve ii of paratype, displaying the nipple-like prolongation or the scar left by its falling away approximately $\times 150$

Figure 8: SEM photograph of a girdle scale of the paratype, showing the structure of the nipple-like prolongation appr. $\times 300$

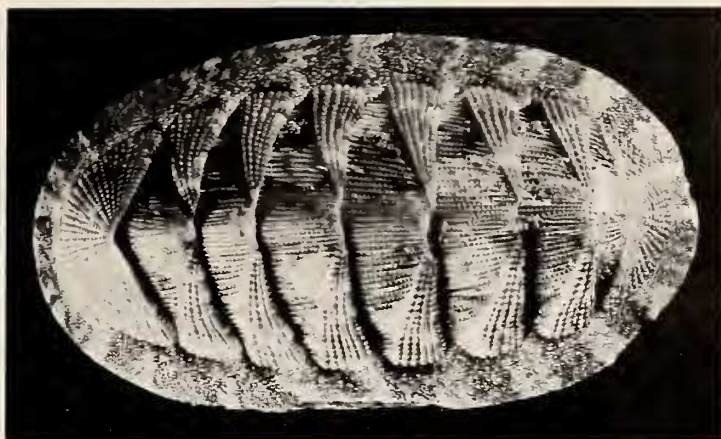


Figure 5

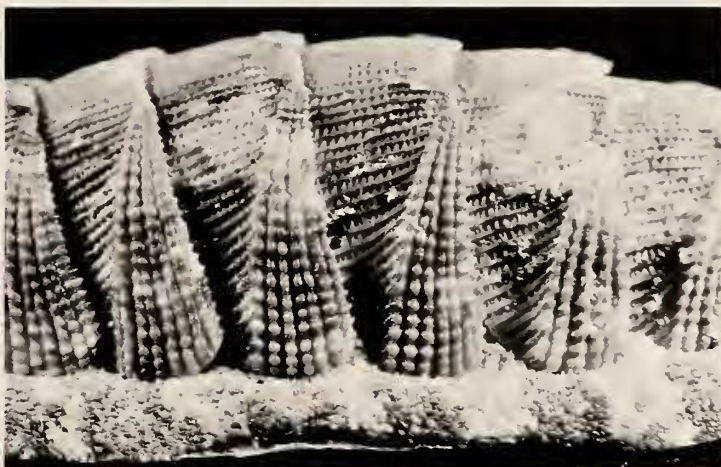


Figure 6



Figure 7



Figure 8

The distribution of *Lepidozona clathrata* seems to be continuous. However, it is a curious fact that in June 1970 two weeks of intense intertidal and subtidal (by means of SCUBA) collecting in the Bahía de Concepcion and adjacent waters up to Isla de Santa Inez and Punta Chivato failed to produce a single specimen of *L. clathrata*.

There have been no authenticated sightings of *Lepidozona clathrata* on the Pacific side of Baja California.

Lepidozona clathrata is usually found on the underside of rocks, often on rocks that rest on sand or mud, from low intertidal to depths that do not seem to exceed 10m of water.

Remarks: The affinities between *Lepidozona clathrata* (Reeve, 1847) and *L. californiensis* Berry, 1931 are well documented in the nomenclatural confusion they have caused. Very likely, both species share an immediate ancestral lineage, representing perhaps an instance of allopatric speciation related to geographical isolation.

Lepidozona formosa Ferreira, spec. nov.

(Figures 5, 6, 7, and 8)

Diagnosis: Chiton about 25 mm long with a many-colored tegmentum, orange, green and pink-rose predominating; central areas longitudinally ribbed and latticed; end valves with many radial ribs made up of well defined, round pustules; lateral areas with about 5 ribs similarly pustulose; girdle of strongly convex, often conspicuously "nippled" imbricating scales.

Description: Holotype (Figures 5 and 6) – Dried, but fully extended, it measures (including girdle) 28.0mm in length, 13.0mm in width, and 9.5mm in height. Jugal angle about 93°. Tegmentum color of very attractive hues: orange-yellow along the jugum and the outer margin of the valves, pea-green in most of the front valve, tail valve, and lateral areas, and a mixture of blotches of pink-rose, white, and dark green through the lateral and central areas, with no discernible pattern to it except for a very definite bilateral symmetry. The anterior valve displays a neat array of ribs which, starting at the apex of the valve, radiate to the periphery and almost invariably dichotomize at mid course; thus, some 20 ribs at the apex become about 46 ribs at the periphery of the valve. Each rib is composed of a compact row of pustules, the pustules very regularly formed and clearly separated from adjacent ones above and below. There are about 16 to 20 such pustules per row, *i. e.*, rib, each becoming larger the closer its location on the valve's outer margin; at the periphery of the valve, the largest pustules reach a diameter of

about 0.5mm. These ribs, or, better, rows of pustules, are clearly separated from each other; the interspaces between pustules in the row, and between the rows of pustules (ribs) show a minutely granulated surface. The posterior valve has a low, inconspicuously flat mucro centrally located. The post-mucro area displays about 30 ribs, composed of pustules, too, similar in every respect to those seen in the front valve. The intermediate valves have moderately elevated areas, bearing some 5 to 7 lateral ribs, made up of similar pustules; each rib is composed of some 20 pustules. The posterior edge of the lateral areas is neatly dentated, the "teeth" appearing definitely different from the pustules by their much elongated antero-posterior diameters; still, the "teeth" correspond both in number (about 20) and in position to the pustules of the adjacent ribs in the lateral areas and to the corresponding longitudinal riblets in the central area. The central areas have some 28 to 30 longitudinal riblets on each side of the midline. These longitudinal riblets are connected by less prominent cross-ribs, about 20 in number, creating rows of squarish pits and an overall lattice effect. Throughout, the longitudinal riblets show a tendency to diverge forward; this tendency is particularly noticeable along the jugum of the second valve where such a divergence, enhanced by a difference in color, contributes to create a "wedge" effect.

The articulamentum is white. Insertion plates are somewhat thick and rugose, regularly cut into straight edged teeth of uniform thickness. Eaves are solid, overhanging moderately. Slit formula is 11-1-12. Sutural laminae are sharp, relatively short and subquadrate. Sinus is moderately wide and a bit shallow; the sinus laminae display some discrete dentations, and some are separated from the sutural laminae by a rather inconspicuous notch. The callus on the inside of valve viii is diffusely tinged with a soft pinkish coloration. The girdle, with a uniform width of about 1.5mm, is regularly banded olive-green and white, with a tendency to become orange at the outer margin and pink at the inner margin. The imbricating scales cover the whole girdle uniformly. The scales are strongly convex with a smooth or minutely granulated surface. Many of the scales, particularly those in the vicinity of the valves' margins, display mammillation of the dorsal edge. These nipple-like formations are much more complex in appearance than similar formations observed on the scales of *Lepidozona clathrata* or *L. mertensii*. In SEM micrographs (Figures 7 and 8: Paratype) these formations appear like minute striated domes conspicuously erected on the dorsal edge of the scale; seemingly, these "nipples" do break off rather easily, leaving in their stead a rather conspicuous "scar" on the scale's surface.

The largest scales, usually located close to the valves, measure about 0.4 mm in length.

Type Locality: The specimen selected as the holotype was found by myself on October 20, 1970, while collecting by means of SCUBA from aboard the R/V *Marisla II*. The specimen was on the underside of a small rock resting on sand in 15 m of water, on the northwest side of Isla San Francisco (24°50' N; 110°35' W), Gulf of California, Mexico.

Type Material: Besides the holotype described above, a second specimen, here designated as paratype, was collected also by myself. This specimen was also found while diving from the R/V *Marisla II* on July 12, 1971, in 20 m of water near a rock formation called "La Reina" on the north side of Isla Cerralvo (24°25' N; 109°57' W), Gulf of California, Mexico. The specimen measured 17 mm in length; the coloration was similar to that of the holotype but with a predominance of pink and green hues, and an almost complete absence of orange. This specimen was used as the subject of the SEM micrographs (Figures 7 and 8). Both holotype and paratype are deposited in the California Academy of Sciences, Department of Geology (CASG), Type Collection, Nos. 55073 and 55074. Color slides (35 mm) of the holotype are deposited in the California Academy of Sciences, Department of Invertebrate Zoology (CASIZ), Color Slide Series. No. 2972.

Remarks: Only 2 specimens of this species have been found so far. *Lepidozona formosa* may be the unnamed species mentioned in KEEN (1971: 875) as "35. *Lepidozona* . . . Thorpe, MS." *Lepidozona formosa* seems to be closely related to *L. clathrata*. The similarities in the general shape, tegmentum sculpture, and girdle scales are striking. In fact, at first, such similarities even imposed the necessity of considering *formosa* as a subspecies of *L. clathrata*. However, a more careful scrutiny showed that the 2 taxa differed immensely not only in color, but in convincingly distinct sculpture and girdle scales (compare Figures 5 and 6 with Figures 7 and 8). As to their habitat, they also seem to differ appreciably, inasmuch as

L. formosa appears to favor a much greater depth than *L. clathrata*.

The species is here called *formosa* for the unusual beauty of its colors and sculptural features. [added in proof: A third specimen of *L. formosa* was collected by myself on November 7, 1973 in about 5 m of water, at "Isla Blanca" (25°48' N; 111°18' W) some 2 km south of Puerto Escondido, Baja California Sur, Mexico. The specimen, 17 mm long, is of uniform tan background color peppered with red-maroon dots throughout; it is retained in the Ferreira Collection.

Lepidozona subtilis Berry, 1956

(Figures 9, 10, 11, and 12)

Lepidozona subtilis BERRY, 1956: 74. — KEEN, 1958: 526 to 527; no. and fig. 42. — DUSHANE, 1962: 50. — DUSHANE & POORMAN, 1967: 438. — DUSHANE & SPHON, 1968: 244-245. — KEEN, 1971: 877-878; no. and fig. 38

Lepidozona pella BERRY, 1963: 137-138; synonymized by THORPE in KEEN, 1971

Diagnosis: Small, arched; color variable and often variegated. End valves with 40-50 radial, minutely beaded ribs. Lateral areas with 5-8 beaded ribs. Central areas with fine longitudinal riblets, with no cross-ribbing. Girdle of relatively small, flattish, striated scales.

Type Locality: "Reef and tide-pools at west end of the long bight of Puerto Peñasco, Sonora, Mexico; S. S. Berry *et al.*, 22-26 March, 1948, 8-9 March, 1949, and subsequent dates." (BERRY, 1956).

Type Material: "Holotype: No. 15,132, Berry Collection. Paratypes: No. 14,962, same collection; others to be deposited in the collections of the U. S. National Museum, Stanford University, and the San Diego Museum." (BERRY, 1956).

Description: Hypotype "A" — (Figures 9 and 10) — Light gray-green in color, with many dark green blotches,

Explanation of Figures 9 to 12

Lepidozona subtilis Berry, 1956

Figure 9: Hypotype "A" (in text), 16.5 mm long

Figure 10: Close-up of lateral and central areas of same specimen

Figure 11: Hypotype "B" (in text): SEM photograph of girdle scales adjoining valve ii approximately $\times 390$

Figure 12: SEM photograph of a girdle scale of hypotype "B", showing the striation approximately $\times 1400$

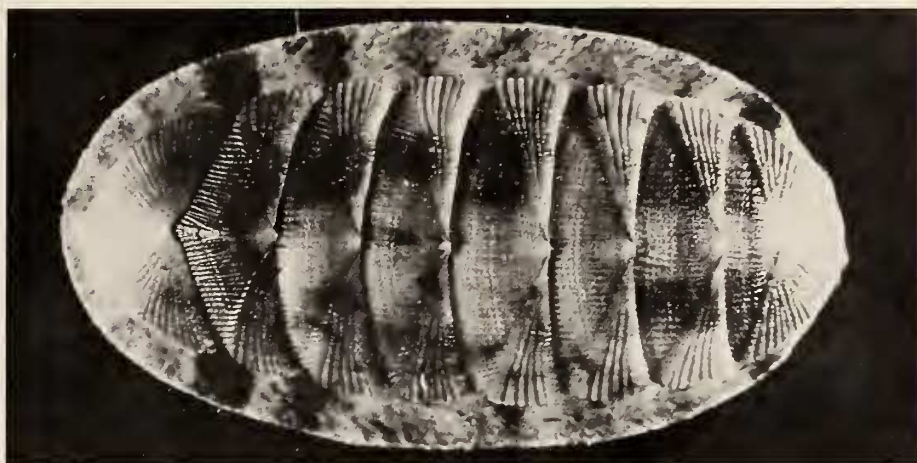


Figure 9



Figure 10



Figure 11



Figure 12

particularly across valve ii (continuing onto the girdle), and ante-mucro area of valve viii. Dried, but fully extended, the specimen measured 16.5 mm in length, 8.8 mm in width, and 2.4 mm in height. Width to length ratio: 0.53. Jugal angle is 112° .

Anterior valve displays about 46 radial ribs, some twinned, made up of minute beads. Posterior valve shows some 30 similar beaded ribs; mucro is well formed and central, with a moderately concave post-mucro area. Lateral areas well defined, bear 5 to 6 similarly beaded ribs, often twinned towards the periphery. Central areas have about 22 to 25 fine longitudinal riblets per side, with no cross-ribbing at all. These longitudinal riblets tend to diverge anteriorly, particularly on valve ii where, at the jugal tract level, they seem to form a wedge-like figure.

The articulamentum has a definitely blue color. Sutural laminae are sharp and well formed, separated by a moderate sized sinus. Sinus laminae are somewhat dentated, and separated from adjacent sutural laminae by rather minute notches. Eaves are solid. Teeth are sharp edged and straight. Slit formula is 12-1-11. Girdle scales flatish and finely striated, attaining a length of 0.2 mm. This specimen was collected by myself, February 1971, at Ensenada Blanca, immediately north of San Felipe, Baja California Norte, Mexico ($31^\circ 03' N$; $114^\circ 49' W$), on the underside of a small rock resting on sand, at low tide, in about 0.5 m of water.

Hypotype "B" - (Figures 11 and 12, SEM micrographs of girdle scales) - Length, 16.0 mm; width, 8.3 mm; also collected by myself, January, 1971, intertidally, at Puerto Peñasco, Sonora, Mexico.

Both specimens, hypotypes A and B, are deposited in the CASG Type Collection (Nos. 55075 and 55076).

Individual Variation: *Lepidozona subtilis* is extremely variable in color. Shades of brown, green, and gray predominate, but white, orange, and even reds are to be seen in many specimens. The same lot may contain a great assortment of colors, some specimens having an almost uniform hue, while others may be quite variegated. There is no apparent correlation between color and size, depth, or geographic location. Occasional specimens show transverse bands of distinctly darker (or lighter) color, a band that cuts across the 7th valve, or the 8th valve, or both, continuing onto the adjacent part of the girdle in a manner very reminiscent of the banding frequently found in *L. mertensii* (Middendorff) of the California faunal province.

Variations in meristic characters (size, ribs, slits, etc.) are summarized in Table 1, the data being based upon the careful examination of 20 seemingly adult specimens collected by Antoinette and Roger Schock and myself,

at Ensenada Blanca and Punta San Felipe, Baja California Norte, Mexico, on February 17 - 19, 1973 (AJF stations 24 and 27).

Distribution: *Lepidozona subtilis* seems to be confined to the northern half of the Gulf of California, Mexico, where it is to be found on the underside of rocks usually resting on sand or mud, from low intertidal to a depth of 2 or 3 m. The distribution appears to be continuous. The literature (KEEN, 1958 and 1971; DUSHANE, 1962; DUSHANE & POORMAN, 1967; DUSHANE & SPHON, 1968) and the collections of the California Academy of Sciences, Allyn G. Smith, George Hanselman, and my own (AJF), reveal that *L. subtilis* has been found from Puerto Peñasco, Puerto Lobos, Bahía de San Pedro, and Guaymas on the Sonora side, and through San Felipe, Puertecitos, Bahía San Luis Gonzaga, Bahía de Los Angeles, to Bahía San Francisco on the west side of the Gulf.

Remarks: Collecting records of *Lepidozona subtilis* indicate that despite the similarity in habitat and anatomical features with *L. serrata*, the two species have non-overlapping ranges of distribution. These allopatric species were found to coexist only in one of the many lots available in the wet invertebrate collection of the California Academy of Sciences, from a locality "some twelve miles south of Puertecitos" (coll. Smith, Wiggins and Leviton, 10 April, 1961, Belvedere Science Fund-Vizcaino Desert Expedition, 1961). Reports of coexistence are limited to Puertecitos (DUSHANE, 1962), and Bahía San Luis Gonzaga (DUSHANE & SPHON, 1968) where *L. subtilis* was found to be "common" but *L. serrata* "rare." By contrast, the sympatry between *L. subtilis* and *L. clathrata* is evident throughout the upper Gulf of California, although *L. subtilis* has a much more restricted range than does *L. clathrata*, both in geography and in depth.

The synonymy of *Lepidozona subtilis* Berry, 1956, with *L. pella* Berry, 1963, was established by THORPE in KEEN, 1971. Still, I looked over the subject anew by examining topotypes in the George Hanselman Collection, several specimens suspect as *L. pella* in my own collection, and 2 paratypes in the Los Angeles County Museum of Natural History ("Paratypes LACM no. 1449, *Lepidozona pella* Berry, 1963. Intertidal, San Felipe, Baja California, Mexico, leg. Eugene Coan and S. S. Berry, January 26, 1963, ex McLean Collection"). The conclusion is definitely in favor of conspecificity. The paratypes of *L. pella* do not differ from *L. subtilis* in size, sculpture, or any other way; they only differ somewhat in their color, which is a rather uniform dark brown. George Hanselman and Gale Sphon (independent personal communications) suggest that such differences in color, if at all worth mentioning, and ob-

Table 1

Comparison of within-species and between-species meristic characters of representatives of the genus *Lepidozona* Pilsbry, 1892, in the Panamic Province. For reference, observations of same-sized sample of *Lepidozona mertensii* (Middendorff, 1847), type species of the genus, are also included

	<i>Lepidozona mertensii</i> (n = 20) Type Species	<i>Lepidozona clathrata</i> (n = 20)	<i>Lepidozona formosa</i> (n = 2) ¹	<i>Lepidozona subtilis</i> (n = 20)	<i>Lepidozona crockeri</i> (n = 20) ¹	<i>Lepidozona serrata</i> (n = 20)	<i>Lepidozona allynsmithi</i> (n = 12) ¹
length (mm)	30-42	20-37	17-28	16-22	19-22	10-17	10-20 ²
width (mm)	16-21	12-22	11-13	9-12	11-13	6-9	5-10 ²
width/length ratio (mean)	0.59	0.62	0.62	0.53	0.58	0.59	0.59
jugal angle (mean)	93°	105°	93°	99°	94°	101°	101°
Tegmentum:							
Valve i—ribs. (no.)	21-40	15-27	30-40	42-54	22-30	20-30	16-24
(mean)	27.7	21.5	35.0	49.6	26.0	24.8	18.9
Valves ii-vii							
central areas							
riblets (no.)	10-14	12-20	16-25	24-32	20-24	10-15	8-12
latticed?	yes	yes	yes	no	yes	yes, "squares"	yes, "diamonds"
"wedge" on ii?	yes	yes	yes	yes	yes	no	no
lateral areas							
ribs (no.)	5-8	3-7	6-8	5-8	3-8	2-4	2-4
(mode)	6	4	6	6	?	2	3
(pustules?)	strong	strong	strong	weak	strong	obsolete	obsolete
Valve viii—ribs (no.)	11-23	11-18	20-28	26-38	20-27	8-16	14-20
(mean)	17.5	16.1	24.0	30.7	23.5	11.3	17.1
Articulamentum:							
Valve i—slits (no.)	8-12	9-15	10-11	10-13	10	9-12	11-13
(mode)	10	11	?	11	?	10	12
Valve viii—slits (no.)	8-11	10-16	12-13	10-17	11	9-13	10-12
(mode)	10	12	?	11	?	10	12
Girdle scales:							
smooth or striated?	smooth	smooth	smooth	striated	striated	striated	striated
mammilated?	yes	yes	yes	no	no	no	no, w/"cotton balls"
maximum length (μm)	500	650	400	240	220	200	200

¹includes type material²n=18

Explanation of Figures 13, 14

Lepidozona crockeri (Willett, 1951)

Figure 13: Hypotype (in text), 19.0mm long

Figure 14: Close-up of lateral and central areas of same specimen



Figure 13

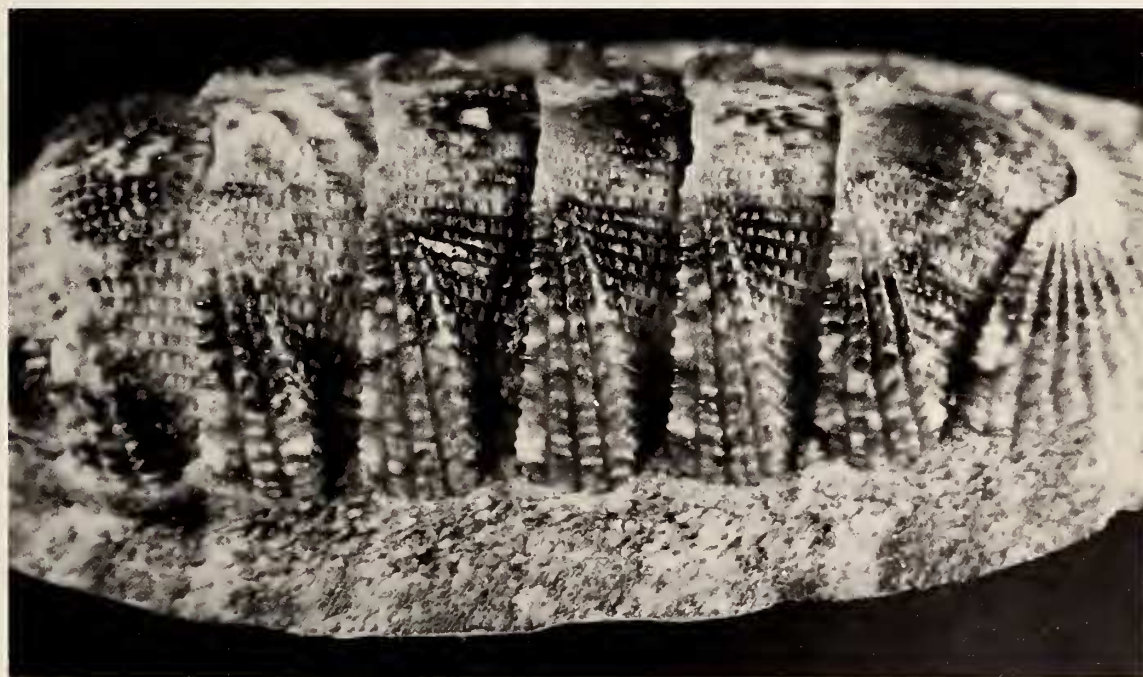


Figure 14

served in some, but not all, specimens collected in San Felipe, may result from the excessive amounts of [diesel?] oil that, from fishing boats at anchor, often streams towards the rocks of Punta San Felipe, where these chitons are relatively abundant. In its original description, BERRY (1963) stated about *L. pella* that "this gloomy species (Gr. *pellos*, dusky) is very near to the previously described *L. subtilis* Berry, 1956, from Puerto Peñasco, differing principally in the strongly granulated terminal and lateral ribbing, much greater number of ribs both radial and longitudinal, dull coloring, and considerably greater size attained." Re-examination of the matter indicates that these differences are well within the range of individual variation of *L. subtilis* and that *L. pella* must be considered as its junior synonym.

Lepidozona crockeri (Willett, in Hertlein & Strong, 1951)

(Figures 13 and 14)

Ischnochiton crockeri WILLETT in HERTLEIN & STRONG, 1951: 114; XI; fig. 12

Lepidozona crockeri. KEEN, 1958: 526-527, no. and fig. 40.
— KEEN, 1971: 874-875; no. and fig. 32

Diagnosis: Chiton of medium size, brown-reddish color. Anterior and posterior valves with many radiating ribs of rounded pustules. Median valves with prominent lateral areas of 6-8 rows of pustulate ribs; central areas with thin, well defined longitudinal riblets, and less prominent cross-ribbing. Girdle with imbricated finely striated scales.

Type Material: Holotype (CASG, Type Collection, No. 9560). Dimensions (exclusive of girdle): "length, 18.4 mm; diameter, 9.6 mm; altitude, 4 mm." (WILLETT in HERTLEIN & STRONG, 1951).

Type Locality: "From Station 150-D-6, Gorda Banks in the Gulf of California off the southern end of lower California, Latitude 23°02'00" N, Longitude 109°31'00" W, dredged in 60 fathoms (109 meters), rocks, muddy sand." (WILLETT, 1951)

Description: Hypotype (Figures 13 and 14) — The reddish-brown shell is generously mottled with white and olive green on all valves. The specimen, dried but fully extended, measures 19.0 mm in length, 11.0 mm in width, and 3.6 mm in height. Width to length ratio = 0.58. Jugal angle is 94°. Tegmentum is minutely granulose. Anterior valve shows some 22 radial ribs, several twinned, made up of a series of about 15 or 16 pustules, rounded to transversely elongated, close together. Posterior valve has some 19 similar ribs; the mucro is flat, inconspicuous,

centrally located. In intermediate valves, the lateral areas bear 3 to 4 similar ribs. Central areas have well defined longitudinal riblets, about 20 in each half of the central area, with somewhat less prominent cross-riblets, 8 to 10 in number, for a distinct lattice effect. The jugum is like a relatively smooth ribbon, 0.5 mm in width, unribbed except on the second valve where jugal riblets diverge forward to make a wedge-like figure.

Articulamentum is whitish throughout. Insertion plates have neatly formed teeth, relatively sharp, though a bit rugose. Slit formula 10-1-11. Sutural laminae are sharp, semioval and relatively small. Sinus is well defined though somewhat shallow; sinus laminae show some occasional small dentations but display no conspicuous notching on their junction with sutural laminae.

The girdle is colored a light reddish-brown, banded with white; width 1.5 mm. The imbricated girdle scales are oval, relatively small (about 0.22 mm for the largest ones), moderately convex, and finely striated. When examined under moderate magnification ($\times 60$), they show no visible mammillation or "nipple" formation such as found in other species of *Lepidozona*. The specimen was collected by myself, on November 23, 1970, while I was diving from the R/V *Marisla II* off Punta Colorado (25°01'N; 110°34'W) on the east side of Isla San Jose, Gulf of California, Mexico, on the underside of a rock resting lightly on sand, at a depth of about 10 m. The specimen is preserved in the Ferreira Collection; 35 mm color slides are deposited at CASIZ, Color Slide Series, Nos. 2973 and 2974.

Remarks: *Lepidozona crockeri* is obviously rare. Thorpe in KEEN, 1971, stated that it was "only known from two specimens." Unfortunately, it was not possible to examine or obtain further data about that other (besides the holotype) specimen, seemingly from the "southern part of the Gulf of California, 20 meters." Thus, the specimen here described and photographed appears to be the first documented finding of *L. crockeri* since its original description in 1951. Compared to the holotype, this specimen is noteworthy for the much more vivid color of the shell and girdle, the smaller number of radial ribs and the much better defined sculpturing. Whether such differences are a function of the possibly greater age and wear of the holotype, or a reflection of individual variations perhaps related to habitat and depth, remains to be seen. The similarity between *L. crockeri* and *L. subtilis* has been emphasized by BERRY (1956) and Thorpe in KEEN (1971); but it seems to me that except for the girdle scales which are rather similar, these two species of chitons stand distinctly apart.

Added in proof:

Another specimen of *Lepidozona crockeri* was collected by myself on June 16, 1974, in about 15m of water, approximately 1.6km north of Isla Monserrate (25°43' N; 111°03' W), Gulf of California, Mexico (AJF-170) while I was diving from the R/V *Disappearance* with Edwin Janss, Jr., and John E. McCosker. The specimen, 14mm long and of a uniform dark plum color, is now in the Ferreira Collection.

Lepidozona serrata (Carpenter, 1864)

(Figures 15, 16, 17, and 18)

Ischnochiton serratus CARPENTER, 1864: 315 [Reprinted, 1872: 213]. — CARPENTER, 1864: 618 [Reprinted 1872: 104]. — PILSBRY, 1892: 122; 1893a: 78; plt. 16, figs. 42-46. — DALL, 1921: 192. — OLDROYD, 1927 2 (3): 278 [in section *Stenoradsia*]. — BURCH, 1947: 18 [in subgenus *Lepidozona*]

Ischnochiton (Lepidozona) serratus. PALMER, 1958: 275-276; plt. 32, fig. 5. — PALMER, 1963: 369

Lepidozona serrata. KEEN, 1958: 526; no. and fig. 41. — DUSHANE, 1962: 50. — DUSHANE & SPHON, 1968: 245. — KEEN, 1971: 875-877, no. and fig. 37

Diagnosis: Small-sized chitons, often uniformly cream colored except for some blotches of a darker color, such as red, green, blue, or black. End-valves with 20 to 30 radial low ribs. Lateral areas with about 2 to 4 similar, wide, flattish ribs. Central areas with longitudinal riblets regularly cross-ribbed resulting in a neat squarish grating appearance. Girdle with moderately convex, finely striated scales.

Type Locality: Cabo San Lucas, Baja California Sur, Mexico, "collected at Cape St. Lucas by Mr. J. Xantus." (CARPENTER, 1864).

Type Material: "Holotype — Formerly U. S. National Museum, no. 16204 (lost); paratype: Redpath Museum, no. 98." (PALMER, 1958)

Description: Hypotype "A" (Figures 15 and 16) — Shell cream colored, with irregular splashes of black in the outer part of the central areas in front of the lateral areas. Specimen dried, but fully extended, measures 11.6 mm in length, 6.4mm in width, 1.9mm in height. Width to length ratio = 0.47. Jugal angle is 105°.

Tegmentum is minutely granulose throughout. Anterior valve displays about 20 low profile, flattish ribs, some twinned, and often neatly separated from each other by a fine sulcus. Posterior valve shows some 13 similar ribs; mucro central, well defined but not conspicuous. Lateral areas moderately raised, show essentially 2 wide, flat ribs, which often dichotomize to become 3 or 4 similar ribs at the periphery. Occasionally some of the ribs, although basically flat, show some indication of faint and obsolete pustules. The posterior border of the lateral areas displays, however, well formed elongated pustules that protrude slightly posteriorly, imparting a "serrate" appearance to the otherwise straight posterior border of the valve. Central areas with about 15 longitudinal riblets (per side) neatly parallel to the jugum, with only minimal indication of diverging forwardly. These longitudinal riblets are transversely joined by equally prominent cross-ribbing, resulting in a clearly defined squarish grating. The jugum is unribbed, relatively smooth, except for the minutely granulose surface characteristic of the whole tegmentum. Valve ii shows no wedge-like figure as seen in other *Lepidozonas*.

Articulamentum is whitish throughout. Sutural laminae are relatively small, and semi-oval; sinus is well formed but a bit shallow; sinus laminae have no visible dentations, and no notches separate them from the adjacent sutural laminae. Eaves are solid. Insertion teeth are relatively sharp, straight edged, well formed. Slit formula is 10-1-11.

Girdle is very faintly banded, with an average width of 0.7mm. The imbricating girdle scales are definitely oval, about 0.2mm long, with fine striations (as shown in SEM micrographs of the hypotype "B", Figures 17 and 18), with no "nipple" formation.

Explanation of Figures 15 to 18

Lepidozona serrata (Carpenter, 1864)

Figure 15: Hypotype "A" (in text), 11.6mm long

Figure 16: Close-up of lateral and central areas of same specimen

Figure 17: Hypotype "B" (in text): SEM photograph of girdle scales adjoining valve ii approximately $\times 300$

Figure 18: Close-up of girdle scales of same specimen as in Figure 17 approximately $\times 1000$